Observations on the Life History and Bionomics of *Oligotoma ceylonica ceylonica* Enderlein (Oligotomidae, Embioptera), commensal in the Nest of the Social Spider *Stegodyphus sarasinorum* Karsch.

BY

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(*With two plates*)

INTRODUCTION

None of the previous workers on social spiders has reported the commensalistic association between these spiders and the Embioptera living in their nests. Marshall (1898) discovered the presence of certain microlepidopteran nest mates of South African social spiders and Pocock (1903) reported commensalism between the social spiders and a moth *Bathrachedra stegodyphobius*. The association of the social spiders and Embioptera is a new record of commensalism. Since the literature shows that the life history and bionomics of even the free living Embiids have not been completely worked out and because all the developmental stages of *Oligotoma ceylonica ceylonica* are met with in the *Stegodyphus* nests, it was thought worthwhile to study the life history and bionomics of this Embiid as completely as possible.

METHODS OF STUDY

Social spider nests were collected from different areas in Feroke (Kerala State) near paddy fields at different periods of the year (Sep. 1964-Sep. 1965), and were dissected and analysed in the laboratory.

Live oligotomids were collected from these spider nests and some of them were reared in captivity in 2 in. petri dishes placed separately in beakers in a glass trough to which a little water was added to keep away ants, cockroaches, etc. The beakers were covered with a net to keep out any flying insects or arachnids.

The oligotomids in the petri dishes were provided with a little *Stegodyphus* nest material and dry twigs obtained from the interior of the nest. A little wheat flour was supplied to them now and then. The dry twigs were slightly moistened daily to maintain proper humidity. Daily observations were made on eggs, immature stages (nymphs), and adults under a stereomicroscope. Observations on the bionomics of *Oligotoma ceylonica ceylonica* were also made in the field on live nests of *Stegodyphus* late in the evenings, at a time when the spiders themselves are active.

Life history

Egg.—Oviposition takes place inside silken tunnels constructed by the mother. The total number of eggs laid by a single individual in its life time varies from 41 to 74 as calculated from the number of eggs laid by individual females in ten cultures in the laboratory, although under natural conditions the number appears to be much higher. The number of eggs laid per day varies from 1 to 3 although in one of the breeding cultures a female laid a total of 4 eggs per day several times. But usually only a single egg is deposited per day. The number of eggs which individual females are capable of laying is much higher in captivity than that recorded by Ananthasubramanian & Ananthakrishnan (1960) who believe that 'the number of eggs laid in captivity is always very limited' (6-15 in *O. minuscula*, 15-24 in *O. humbertiana*). Ling (1934) stated that 'each female of *O. saundersii* probably does not produce more than ten eggs'.

The eggs are deposited in a linear row, their opercular ends always directed anteriorly facing the roof of the tunnel, sometimes slightly overlapping each other (Plate I, fig. 1). If frequently disturbed they may lay without any such symmetry and arrangement, and deposit haphazardly on the inner surface of the silken tunnels. In *Stegodyphus* nests the eggs are laid in dry regions in the interior, where dark, humid, and favourable environmental conditions prevail. In captivity the egg-laying period varies from one to two-and-a-half months. The eggs are not laid continuously every day, as once or twice in a fortnight no eggs were deposited.

Each egg (Plate I, fig. 2) is more or less elongate, creamy white in colour, with a glistening surface when laid. The pear-shaped operculum is marked off from the rest of the egg by a thick whitish fold all along its margin. The average size of the egg is 0·89 mm. in length and 0·41 mm. in diameter.

Incubation period. 19 to 22 days, depending upon the period of the year. During development, the egg shows a slight change from white to opaque dull colour (due to the developing embryo inside) and later two rounded eye spots are visible through the chorion on either side of the opercular end, representing the eyes of the embryo inside.

First Instar Nymph (Plate I, fig. 3). The newly hatched nymph is pale-coloured and almost transparent. It can feed by itself, moves about actively, spins small tunnels and avoids daylight. It measures 1·4 to 1·5 mm. in length. The head is much wider than any other part of the body and measures 0·45×0·39 mm.; the thorax and abdomen are subequal in length. The eyes are blackish and the tips of the dentate mandibles are reddish brown. The head, shaped as in the figure, bears 9-segmented antennae which are nearly as long as the head. The first and second segments of the antennae are short and wide, 3rd segment long and rest of the segments as shown in the figure. The pro-, meso-, and metanota are subequal; the abdomen is 10-segmented, but the 10th segment is not clearly marked from the rest of the abdomen.

The fore tarsi of the nymph are swollen and contain spinning glands. The last pair of legs has a single metatarsal sole, bladder-like as in the adult. Cerci two-segmented, symmetrical, 1st segment smaller in length than the second segment. The body is wholly covered with pale-coloured setae, which are shorter on the antennae and longer on the cerci. The first instar moults into the second instar after 9-12 days. Just prior to moulting it measures *c.* 2·5 mm. in length.

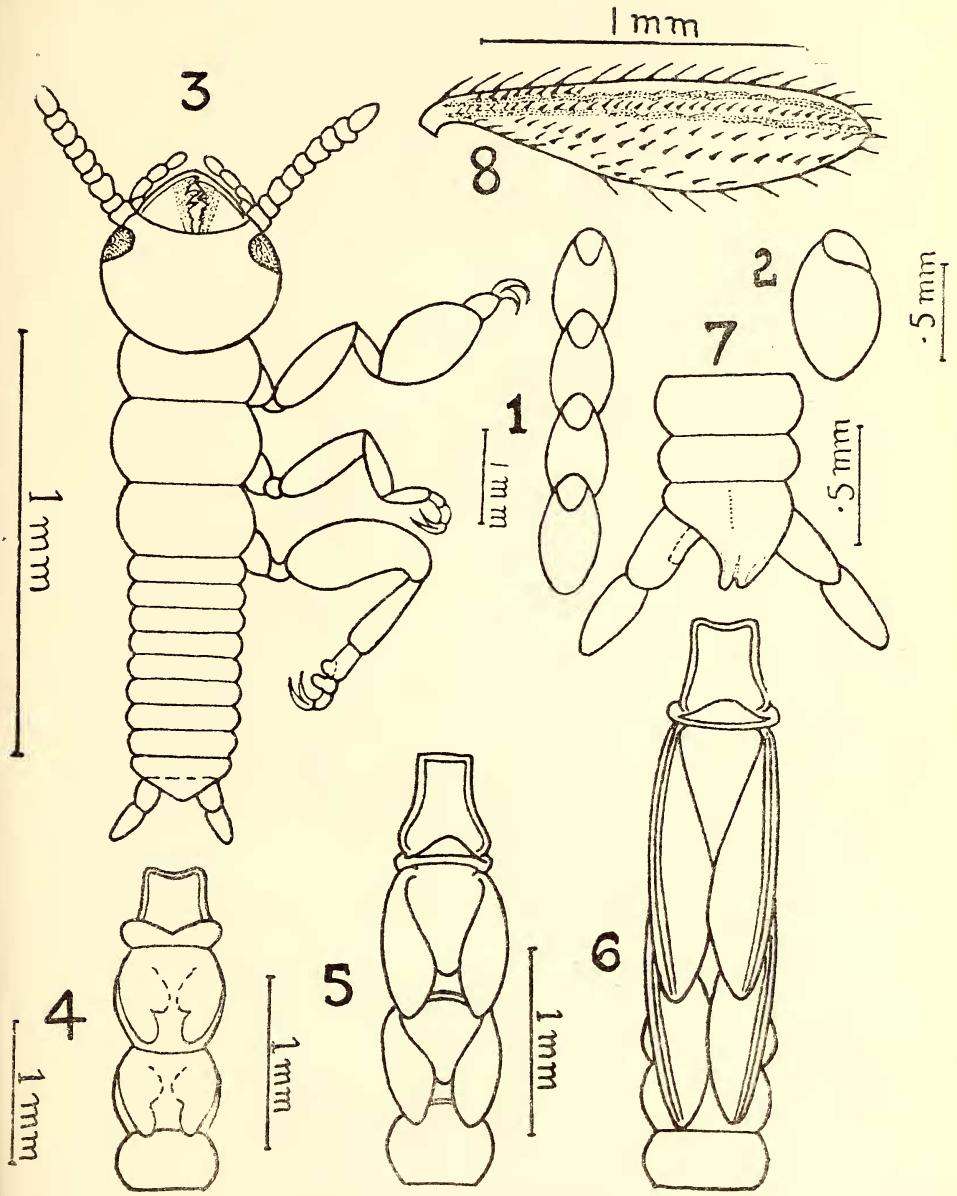
Second Instar Nymph. Pale-yellowish in colour measuring 2·8-3·6 mm. in length, with head 0·56×0·45 mm., thorax 1·18-1·41 mm., and abdomen 1·24-1·54 mm. This nymph differs from the first instar nymph in having a 12-segmented antenna, which is distinctly longer than its own head. It has 10 distinct segments in the abdomen; prothorax is narrower; 10th sternum divided into two parts by a median groove. Antennae, maxillary and labial palps, and legs are still pale-coloured. No sexual dimorphism is noticed in this stage. The second instar nymph moults into the third instar after 10-12 days. Just prior to moulting it measures *c.* 3·5 mm. in length.

Third Instar Nymph. The third antennal segment of the second instar nymph divides into two segments, and thus the third instar possesses

a 13-segmented antenna. The antenna in this instar is about twice as long as its own head. The fourth and sixth segments of the antenna are the smallest in length. The male nymphs have small wing buds (Plate I, fig. 4) which are absent in the female nymphs. Only the tips of the wing buds are clearly visible. The wing buds in *O. ceylonica ceylonica* appearing in the third instar nymph thus develop at a very early stage in the life history as compared with the other species of *Oligotoma* studied. The nymphal stage with wing pads has been reported to be the 5th instar, both in the case of *O. humbertiana* (Ananthasubramanian 1956) and of *O. minuscula* (Ananthasubramanian & Ananthakrishnan 1960). The nymph is slightly pigmented and measures 4·18-5·50 mm. in total length. Its thorax is 1·5-2 mm. in length and the abdomen 1·9-2·9 mm. After about 10-13 days the third instar moults into the 4th instar nymph.

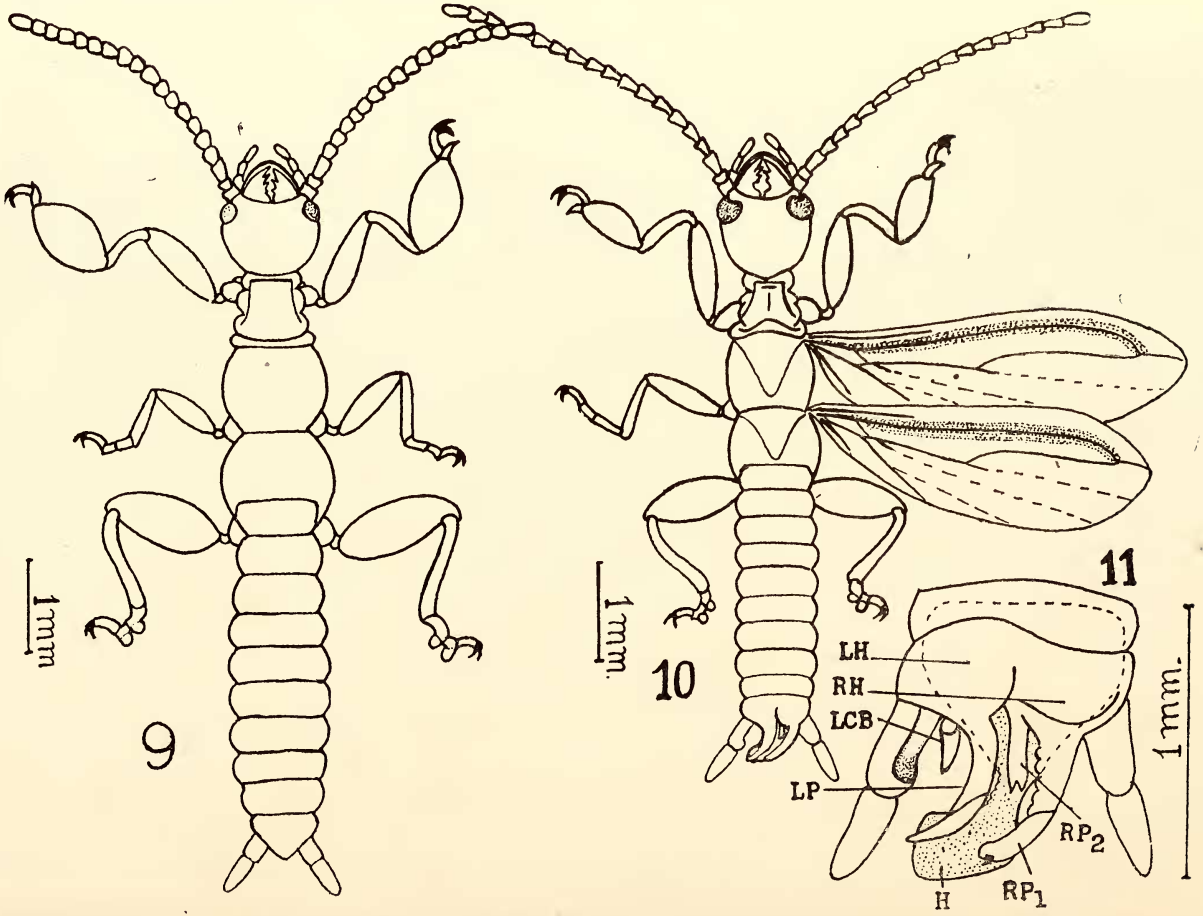
Fourth Instar Nymph. 5·5-5·8 mm. in length and about twice as long as the second instar. The head is 0·84×0·67 mm.; thorax 2·1-2·2 mm., and abdomen 2·6-2·7 mm. The cerci are symmetrical. Antennae 1·35 mm. long and 15-segmented as a result of the division of the 3rd antennal joint of the previous nymph into 3 segments, prior to moulting. Basal part of each antennal segment exhibits accumulation of light-brownish pigments in the form of a ring. Wing pads (Plate I, fig. 5) have grown in size and are completely visible measuring 0·56 mm. in length. They are dirty-white and are covered with loosely arranged setae. The 8th sternum of the female nymph shows a round unpigmented area where the female genital opening appears in the next instar. After 13-15 days the 4th instar moults into the 5th instar.

Fifth Instar Nymph. Pale-brown in colour; length varies from 5·15 to 6·66 mm. The male nymphs are usually smaller than the females and have more slender body. The male head measures 0·84×0·67 mm. and female head 0·96×0·84 mm. In the male nymph the wing pads have grown considerably in size and have become membranous. They bear linear rows of setae which demarcate the future veins. The anterior pair of wing pads extend up to the anterior margin of the first abdominal segment and the posterior pair to the anterior margin of the 3rd abdominal segment (Plate I, fig. 6). Each wing pad measures 1·2-1·4×0·39 mm. Two marginal pigment lines very near to each other run along the outer margin of each wing pad. Similar marginal lines have also been found in the wing pads of the male nymph of *O. texana* (Mills 1932). He believes these pigment lines to be the forerunners of the brown lines which are found on each side of the R_1 vein in the fully developed wing.



Oligotoma ceylonica ceylonica Enderlein

Fig. 1. Alignment of 4 eggs as seen from above; Fig. 2. Sideview of an egg with operculum at the anterior end; Fig. 3. The newly hatched nymph; Fig. 4. Thorax and first abdominal segment to show early stage in the development of wing (in 3rd instar nymph); Fig. 5. Same at a later stage (in 4th instar nymph): Fig. 6. Same in the 3rd stage of development (as seen in 5th instar nymph); Fig. 7. Distal end of the abdomen of a grown up 5th instar male nymph; Fig. 8. Fourth stage in the development of wing (as seen in a later stage nymph);



Oligotoma ceylonica ceylonica Enderlein

Cercus-basipodite; LH: [illegible]; RH: [illegible]; LCB: [illegible]; LP: [illegible]; RP2: Inner process of the right hemitergite; RP1: Tenth right hemitergite;

Antennae in both sexes 16-or-17-segmented, measuring 1·7-1·9 mm. in length. In the female nymph the genital opening is visible on the 8th sternum. In a grown-up male nymph the 10th tergum which is asymmetrical, shows a median depression and its tip bears two projections (Plate I, fig. 7) representing the two developing processes of the right and the left 10th hemitergites. These features, however, are transitory and after 10-13 days striking changes are noticed in antennae, head shape, mandibles, cerci, size and pigmentation of the whole body, 10th tergum and wing pads. The wing pads become thick and plate-like with distinct rows of setae, and the marginal pigment lines (already mentioned above) are seen wide apart from each other, running irregularly towards the tip of each wing-pad (Plate I, fig. 8). On the other hand the female nymphs attain maturity and grow larger in size without undergoing any of the changes mentioned above in the case of the male, except in the antennae and the general pigmentation of the body.

The nymphs make thick-walled tunnels and move very little now. Prior to the final moult which takes place within 3-5 days the male and female nymphs measure 5·4-6·7 mm. The total duration from the beginning of the fifth instar nymph to the final moult lasts 13-20 days.

Adult. The number of segments in each antenna of both sexes varies from 19 to 20. The measurements are as follows: MALE (Plate II, fig. 10) total length 6·2-6·31 mm., head 0·9×0·7 mm., anterior wing 4·5-4·6 mm., posterior wing 3·6-3·8 mm.; FEMALE total length 7·4-7·9 mm., head 0·96-1×0·8 mm. The female *O. ceylonica ceylonica* (Plate II, fig. 9) is larger in size and has much darker-brown coloration and a broad oval head. Its antennal segments are shorter in length. According to Davis (1940) 'adult male *O. ceylonica ceylonica* is recognisable by the first segment of the left cercus being less excavate in the basal three quarters and by the absence of the outcurved spine on the left cercus-basipodite'. The terminalia of the adult male of *O. ceylonica ceylonica* is shown in Plate II, fig. 11.

BIONOMICS

Habits. *Oligotoma ceylonica ceylonica* is nocturnal in habits like its spider host. It lives in sub-societies inside silken tunnels, which are constructed in the interior of the spider nest. These tunnels traverse the nest in the form of a network along the intercommunicating tunnels of the spiders. These silken tunnels of oligotomids communicate with the external environment through short branches spun on the surface

of the nest and are provided with several small exit holes. The outer tunnels present on the surface serve as exits, especially for the adult males who fly away soon after copulation. They also lead to the green algal growths (on the exterior of the spider nest) serving as food for the nymphs. Sometimes, from the interior of the spider nest these silken tunnels penetrate into hollows of the wooden supports on which *Stegodyphus sarasinorum* construct their nests.

Sex ratio. Twenty-eight *Stegodyphus* nests analysed in different periods of the year yielded in all 203 oligotomids, consisting of 7 adult males, 28 adult females, 44 male nymphs, and 124 female nymphs (including many 1st and 2nd instar nymphs). Besides, a large number of eggs were also collected. All these nests were taken from Feroke (Kerala State) from the fencing around paddy fields. The maximum number of individuals collected from a single nest was 39. The adult males are very rarely found in the nest because, as stated above, they fly away soon after copulation. A correct assessment of the sex-ratio, therefore, can be made only from a count of the sexes taken in the nymphal stages soon after sex differentiation has taken place.

Copulation. The females become mature in the 5th instar even before the final moult, thus protogyny is the rule in *O. ceylonica ceylonica.* Copulation takes place inside the silken tunnels and has been briefly described by Melander (1903) in *Embia texana.* My observations confirm his studies. A day after copulation the female started oviposition. The fertilized female chases away approaching adult males from near her eggs. An unfertilized female was seen to extend its silken tunnels and to make many exit holes. This female survived for seventy-two days and did not lay any eggs.

As the eggs and immature stages of *O. ceylonica ceylonica* were available throughout the year, there is sufficient reason to believe that this species breeds all through the year. Ananthasubramanian & Ananthakrishnan (1960) reported a similar observation on breeding in *O. minuscula.* Since the life cycle is completed within 55-72 days in *O. ceylonica ceylonica,* it may be concluded that there may be 4 to 6 generations in one year. In *O. humbertiana* life history is completed within 111 to 158 days and in *O. minuscula* within 72 to 101 days (Ananthasubramanian & Ananthakrishnan 1960). The number of generations of these two species, when calculated, will be about 2 and 4 generations respectively. For *O. texana,* Mills (1932) reports only one generation a year. The breeding of *O. ceylonica ceylonica* throughout the year and the existence of 4 to 6 generations in the year may be ascribed to the abundance of food and other favourable